

locomotive test cycle described in Table 1 to § 1033.515, including transitions from one notch to the next. This is your reference cycle for validating your cycle. You may ignore points between the end of the sampling period for one mode and the point at which you change the notch setting to begin the next mode.

(2) Keep the temperature of the air entering the engine after any charge air cooling to within 5 °C of the typical intake manifold air temperature when the engine is operated in the locomotive under similar ambient conditions.

(3) Proceed with testing as specified for testing complete locomotives as specified in paragraphs (a) through (f) of this section.

§ 1033.520 Alternative ramped modal cycles.

(a) Locomotive testing over a ramped modal cycle is intended to improve measurement accuracy at low emission levels by allowing the use of batch sampling of PM and gaseous emissions over multiple locomotive notch settings. Ramped modal cycles combine multiple test modes of a discrete-mode steady-state into a single sample period. Time in notch is varied to be proportional to weighting factors. The ramped modal cycle for line-haul locomotives is shown in Table 1 to this section. The ramped modal cycle for switch locomotives is shown in Table 2 to this section. Both ramped modal cycles consist of a warm-up followed by three test phases that are each weighted in a manner that maintains the duty cycle weighting of the line-haul and switch locomotive duty cycles in § 1033.530. You may use ramped modal cycle testing for any locomotives certified under this part.

(b) Ramped modal testing requires continuous gaseous analyzers and three separate PM filters (one for each phase). You may collect a single batch sample for each test phase, but you must also measure gaseous emissions continuously to allow calculation of notch caps as required under § 1033.101.

(c) You may operate the engine in any way you choose to warm it up. Then follow the provisions of 40 CFR part 1065, subpart F for general pre-test

procedures (including engine and sampling system pre-conditioning).

(d) Begin the test by operating the locomotive over the pre-test portion of the cycle. For locomotives not equipped with catalysts, you may begin the test as soon as the engine reaches its lowest idle setting. For catalyst-equipped locomotives, you may begin the test in normal idle mode if the engine does not reach its lowest idle setting within 15 minutes. If you do start in normal idle, run the low idle mode after normal idle, then resume the specified mode sequence (without repeating the normal idle mode).

(e) Start the test according to 40 CFR 1065.530.

(1) Each test phase begins when operator demand is set to the first operator demand setting of each test phase of the ramped modal cycle. Each test phase ends when the time in mode is reached for the last mode in the test phase.

(2) For PM emissions (and other batch sampling), the sample period over which emissions for the phase are averaged generally begins within 10 seconds after the operator demand is changed to start the test phase and ends within 5 seconds of the sampling time for the test mode is reached. (see Table 1 to this section). You may ask to delay the start of the sample period to account for sample system residence times longer than 10 seconds.

(3) Use good engineering judgment when transitioning between phases.

(i) You should come as close as possible to simultaneously:

(A) Ending batch sampling of the previous phase.

(B) Starting batch sampling of the next phase.

(C) Changing the operator demand to the notch setting for the first mode in the next phase.

(ii) Avoid the following:

(A) Overlapping batch sampling of the two phases.

(B) An unnecessarily long delay before starting the next phase.

(iii) For example, the following sequence would generally be appropriate:

(A) End batch sampling for phase 2 after 240 seconds in notch 7.

(B) Switch the operator demand to notch 8 one second later.

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(C) Begin batch sampling for phase 3 one second after switching to notch 8.

(4) If applicable, begin the smoke test at the start of the first test phase of the applicable ramped modal cycle. Continue collecting smoke data until the completion of final test phase. Refer to §1033.101 to determine applicability of the smoke standards and §1033.525 for details on how to conduct a smoke test.

(5) Proceed through each test phase of the applicable ramped modal cycle in the order specified until the test is completed.

(6) If you must void a test phase you may repeat the phase. To do so, begin with a warm engine operating at the notch setting for the last mode in the previous phase. You do not need to repeat later phases if they were valid. (NOTE: you must report test results for all voided tests and test phases.)

(7) Following the completion of the third test phase of the applicable ramped modal cycle, conduct the post sampling procedures specified in 40 CFR 1065.530.

TABLE 1 TO § 1033.520.—LINE-HAUL LOCOMOTIVE RAMPED MODAL CYCLE

RMC test phase	Weighting factor	RMC mode	Time in mode (seconds)	Notch setting
Pre-test idle	NA	NA	600 to 900	Lowest idle setting. ¹
Phase 1	A	600	Low Idle. ²	Normal Idle.
(Idle test)	0.380	B	600	
Phase Transition				
	C	1000	Dynamic Brake. ³	Notch 5.
	1	520	Notch 1..	
	2	520	Notch 2..	
	3	416	Notch 3..	
	4	352	Notch 4..	
Phase 2	0.389	5	304	
Phase Transition				
	6	144	Notch 6..	Notch 8.
	7	111	Notch 7..	
Phase 3	0.231	8	600	

¹ See paragraph (d) of this section for alternate pre-test provisions.

² Operate at normal idle for modes A and B if not equipped with multiple idle settings.

³ Operate at normal idle if not equipped with a dynamic brake.

TABLE 2 TO § 1033.520.—SWITCH LOCOMOTIVE RAMPED MODAL CYCLE

RMC test phase	Weighting factor	RMC mode	Time in mode (seconds)	Notch setting
Pre-test idle	NA	NA	600 to 900	Lowest idle setting. ¹
Phase 1	A	600	Low Idle. ² .	Normal Idle.
(Idle test)	0.598	B	600	
Phase Transition				
Phase 2	1	868	Notch 1..	Notch 5.
	2	861	Notch 2..	
	3	406	Notch 3..	
	4	252	Notch 4..	
	0.377	5	252	
	Phase Transition			
Phase 3	6	1080	Notch 6..	Notch 8.
	7	144	Notch 7..	
	0.025	8	576	

¹ See paragraph (d) of this section for alternate pre-test provisions.

² Operate at normal idle for modes A and B if not equipped with multiple idle settings.

(f) Calculate your cycle-weighted brake-specific emission rates as follows:

(1) For each test phase j :

(i) Calculate emission rates (E_{ij}) for each pollutant i as the total mass emissions divided by the total time in the phase.

(ii) Calculate average power (P_j) as the total work divided by the total time in the phase.

(2) For each pollutant, calculate your cycle-weighted brake-specific emission rate using the following equation, where w_j is the weighting factor for phase j :

$$E_{ij} = \frac{w_1 E_{i1} + w_2 E_{i2} + w_3 E_{i3}}{w_1 P_1 + w_2 P_2 + w_3 P_3}$$

§ 1033.525 Smoke testing.

This section describes the equipment and procedures for testing for smoke emissions when is required.

(a) This section specifies how to measure smoke emissions using a full-flow, open path light extinction smokemeter. A light extinction meter consists of a built-in light beam that traverses the exhaust smoke plume that issues from exhaust the duct. The light beam must be at right angles to the axis of the plume. Align the light beam to go through the plume along the hydraulic diameter (defined in 1065.1001) of the exhaust stack. Where it is difficult to align the beam to have a path length equal to the hydraulic diameter (such as a long narrow rectangular duct), you may align the beam to have a different path length and correct it to be equivalent to a path length equal to the hydraulic diameter. The light extinction meter must meet the requirements of paragraph (b) of this section and the following requirements:

(1) Use an incandescent light source with a color temperature range of 2800K to 3250K, or a light source with a spectral peak between 550 and 570 nanometers.

(2) Collimate the light beam to a nominal diameter of 3 centimeters and an angle of divergence within a 6 degree included angle.

(3) Use a photocell or photodiode light detector. If the light source is an

incandescent lamp, use a detector that has a spectral response similar to the photopic curve of the human eye (a maximum response in the range of 550 to 570 nanometers, to less than four percent of that maximum response below 430 nanometers and above 680 nanometers).

(4) Attach a collimating tube to the detector with apertures equal to the beam diameter to restrict the viewing angle of the detector to within a 16 degree included angle.

(5) Amplify the detector signal corresponding to the amount of light.

(6) You may use an air curtain across the light source and detector window assemblies to minimize deposition of smoke particles on those surfaces, provided that it does not measurably affect the opacity of the plume.

(7) Minimize distance from the optical centerline to the exhaust outlet; in no case may it be more than 3.0 meters. The maximum allowable distance of unducted space upstream of the optical centerline is 0.5 meters. Center the full flow of the exhaust stream between the source and detector apertures (or windows and lenses) and on the axis of the light beam.

(8) You may use light extinction meters employing substantially identical measurement principles and producing substantially equivalent results, but which employ other electronic and optical techniques.

(b) All smokemeters must meet the following specifications:

(1) A full-scale deflection response time of 0.5 second or less.

(2) You may attenuate signal responses with frequencies higher than 10 Hz with a separate low-pass electronic filter with the following performance characteristics:

(i) Three decibel point: 10 Hz.

(ii) Insertion loss: 0.0 ± 0.5 dB.

(iii) Selectivity: 12 dB down at 40 Hz minimum.

(iv) Attenuation: 27 dB down at 40 Hz minimum.

(c) Perform the smoke test by continuously recording smokemeter response over the entire locomotive test cycle in percent opacity to within one percent resolution and also simultaneously record operator demand set point (e.g., notch position). Compare